CNTT-E-115

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BASIC ELECTRICITY AND ELECTRONICS

STUDENT HANDOUT NO. 208

SUMMARIES PROGRESS CHECKS FOR MODULES

23 LESSONS 1&2

JUNE 1984

U.S. NAVY NAVAL TECHNICAL TRAINING

SUMMARY
LESSON 1

Bistable Multivibrator Operation (Flip-Flop)

Bistable multivibrators operate like two-position electronic switches. The bistable multivibrator circuit is frequently known as a flip-flop, because it has the ability to "flip" rapidly to one state or "flop" rapidly back to the other state. In either of its two states, the flip-flop is stable.

A flip-flop schematic is shown in Figure 1.

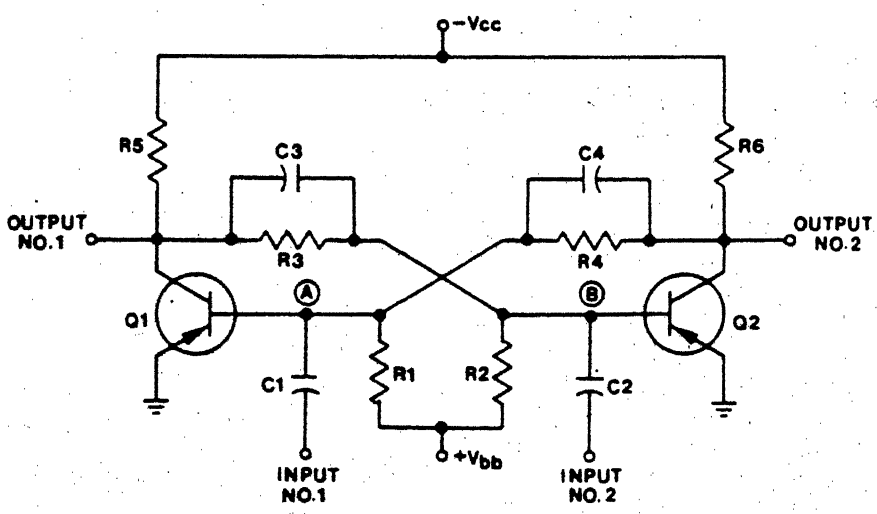


Figure 1

When the flip-flop is first energized, one transistor will go to cut-off and the other transistor will saturate. At no time can both transistors be saturated, and at no time can both transistors be cut-off. When one output measures a high voltage, the other output must be a low voltage.

The flip-flop can be made to change states by either applying a positive-going pulse to the saturated transistor (causing it to cut-off), or by applying a negative-going pulse to the cut-off transistor (causing it to saturate). Normally, a pulse is applied to the saturated transistor. This pulse is called a "trigger" pulse.

The block diagram symbol for a flip-flop circuit is shown in Figure 2.

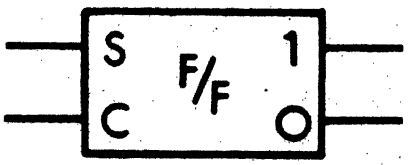


Figure 2

The two inputs are designated Set (S) and Clear (C). The two outputs are identified as "1" and "0". A trigger pulse on the Set input will cause the "1" output to go either positive or negative depending on the type of transistors used. At the same time the "0" output will equal zero volts. If the "1" output measures high voltage, the "0" output must measure a low voltage -- usually zero volts.

A clear state exists when the "1" output measures low voltage and the "0" output measures high voltage. The flip-flop will flop to the clear state only upon application of an enabling pulse to the Clear (C) input.

There is a third input lead on some flip-flops. This input lead is the "Toggle" (T) input as shown in Figure 3.

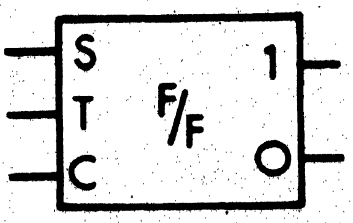


Figure 3

Every time a positive pulse is applied to the "T" input, the flip-flop will change states. This is accomplished with a diode steering network as shown in Figure 4. (Note that if NPN transistors were used the diodes would have to be reversed and the "T" input signal would have to be negative.)

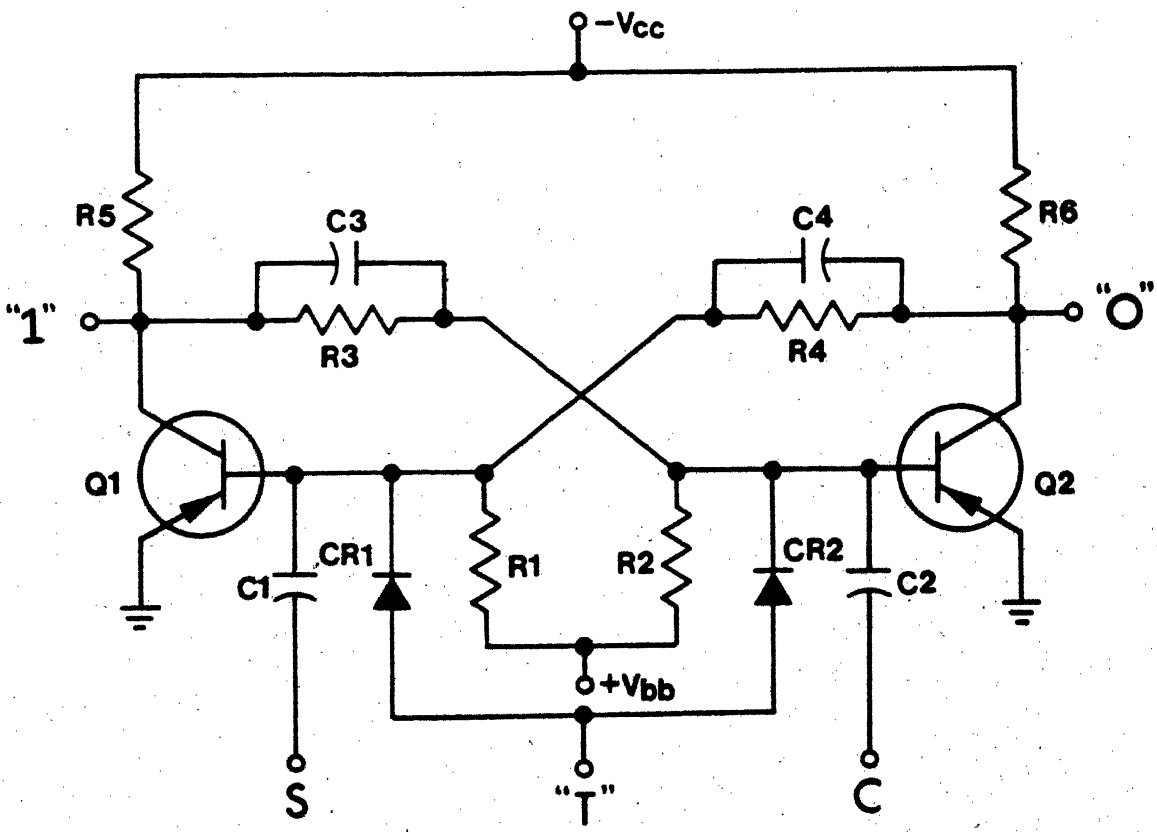


Figure 4

This steering network (CR1, CR2) will steer a positive input pulse to the saturated transistor — causing it to cut off.

For example, Figure 5 shows a sequence of input pulses and output voltage changes for a flip-flop originally in a clear state.

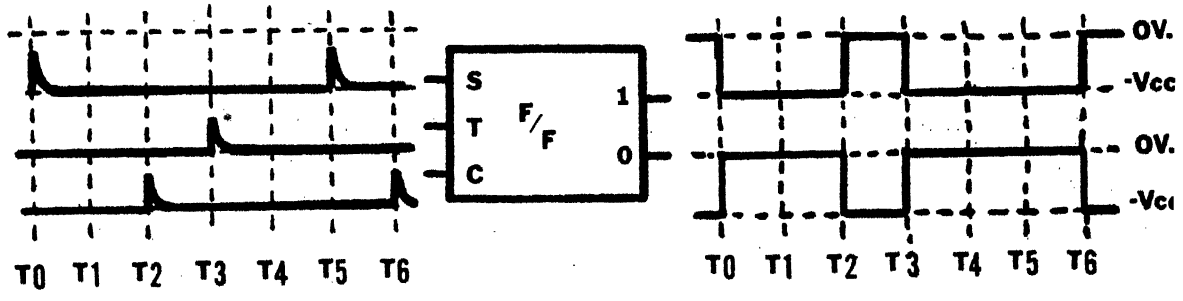


Figure 5

AT THIS POINT, YOU MAY PROCEED TO THE JOB PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

AUDIO VISUAL RESPONSE SHEET

Lesson I

Bi-Stable Multivibrators

1. (A) R2, R3, R5

 (B) R1, P4, R6

2. A B C D (CIRCLE ONE)

3. (A) Output "1"

 (B) Output "0"

4. A B C D (CIRCLE ONE)

5. DRAW THE OUTPUT.

6. DRAW THE OUTPUT.

NOTES

EQUIPMENT AND MATERIALS

1. Oscilloscope
2. Device 6F16, TEMPLATE "G"
3. IX probe (three required)
4. Jumper wire

PROCEDURE

I. Using all applicable safety precautions, energize the oscilloscope, obtain a line trace, and make the following settings:

 a. DISPLAY MODE to "Chop".
 b. VOLTS/DIV (both channels) 5 volts/div.
 c. TIME/DIV to .5 millisec/div.
 d. AC/DC to "DC" (both channels).
 e. Set channel "1" line trace 2 divisions above center line. Set channel "2" line trace 1 division below center line.
 f. Connect IX probes to channel "1" and "2" inputs.

II. Using all applicable safety precautions, set up Device 6F16 as follows:

 a. Set up 6F16 using Template #G (Flip Flop multivibrator) and the parts called for by the template.
 b. Connect one end of a jumper to + 4 volts, (+ volt "battery" jack or the bottom of R3 or R6) leaving the other end loose.
 c. Connect channel "1" probe to the "1" output (Q1 collector).
 d. Connect channel "2" probe to the "0" output (Q2 collector).
 e. Energize the 6F16 using the line cord.

NOTE: Grounding of IX Probe to 6F16 is necessary.

III. Now you are ready to observe the operation of the multivibrator.

1. What is the DC voltage level at the "1" output? _____ VDC

2. What is the DC voltage level at the "0" output? _____ VDC

3. Which transitor is conducting? _____

4. The initial state of the multivibrator is determined by _____ _____.

5. Connect one end of the jumper wire to the +4 Volts source on the 6F16. Using the free end of the jumper, momentarily touch the anode of CR-1. Did the flip-flop change states?

_____.

6. Momentarily apply +4 volts to the anode of CR 2. Did the flip-flop change states?

7. What conduction states are the transistors in now? Q1 _____, Q2 _____.

8. Touch the jumper to the anode of CR2 again. Did the flip-flop change states? _____.

9. Touch the jumper to the anode of CR1. Did the flip-flop change states? _____.

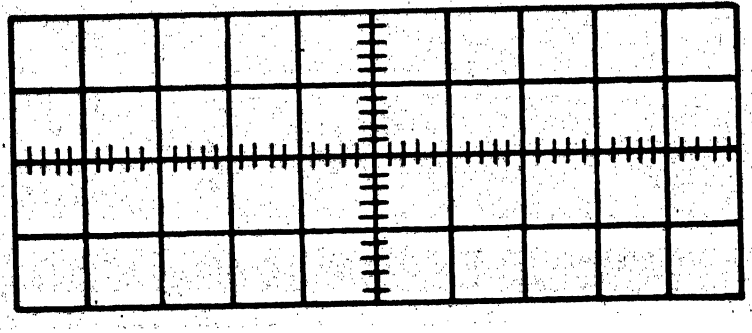
10. What conduction states are the transistors in now? Q1 _____, Q2 _____.

IV. The following procedure will demonstrate the flip-flop action with a series of pulses applied to the circuit.

1. Remove the jumper from the +4 volt source.

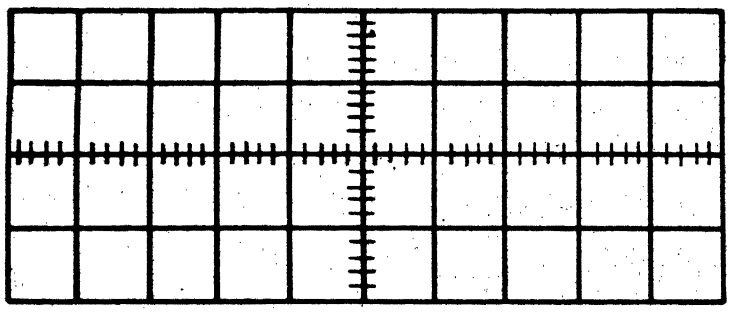
2. Connect a third IX Probe to the oscilloscope calibrator output jack and set the calibrator output to 20 Volts, or to square wave signal generator with 20v pk-pk, 1KHz. Connect the other end of the IX Probe to the shorting strap that is connected between C1 and C2. You now have a 1KHz square wave input applied to C1 and C2. C1 - CR1 and C2 - CR2 are used in this circuit to shape the square wave input into positive triggers that are applied to the base of each of the transistors.

3. Observe the outputs at the collectors of the two transistors and draw the observed waveforms in the graticule below. If no signal is seen, momentarily de-energize the 6F16.



4. Disconnect the probe from the "O" output (oscilloscope channel 2), and reconnect it to the shorting strip between C1 and C2. Set channel 2 VOLTS/DIV to 20 V/DIV. Channel 2 of the oscilloscope will now display the input signal.

5. Draw the waveform displayed on the oscilloscope in the space below.



6. What is the frequency relationship between the input (Channel "2") and the output (Channel "1")? _____

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

PROGRESS CHECK
LESSON I

Bistable Multivibrators

1. The bistable (flip-flop) multivibrator has _____ stable states.

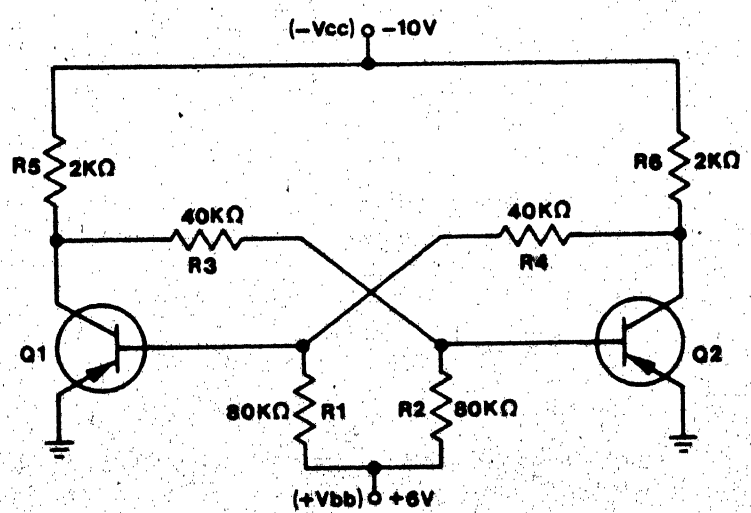
2. Bistable (flip-flop) multivibrators act like a two-position electronic _____.

3. The flip-flop (bistable) multivibrator (will/will not) change states when an external trigger of the correct amplitude is applied at the proper input.

4. The flip-flop (bistable) multivibrator has two inputs and _____ output(s).

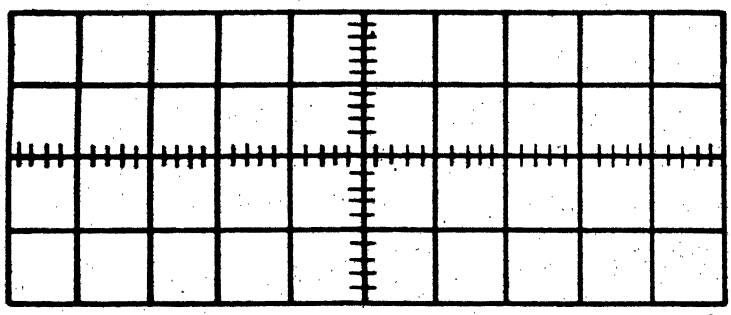
5. In a flip-flop multivibrator, when one transistor is saturated, the other transistor must be _____.

6. In the circuit illustrated, which voltage divider network supplies the bias potential to the base of Q1? _____.



7. To change the state of a flip-flop multivibrator (illustrated in question #6), a (positive/negative) pulse may be applied to the base of the saturated transistor.

5. Draw the waveform displayed on the oscilloscope in the space below.



6. What is the frequency relationship between the input (Channel "2") and the output (Channel "1")? _____

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

PROGRESS CHECK
LESSON I

Bistable Multivibrators

1. The bistable (flip-flop) multivibrator has _____ stable states.

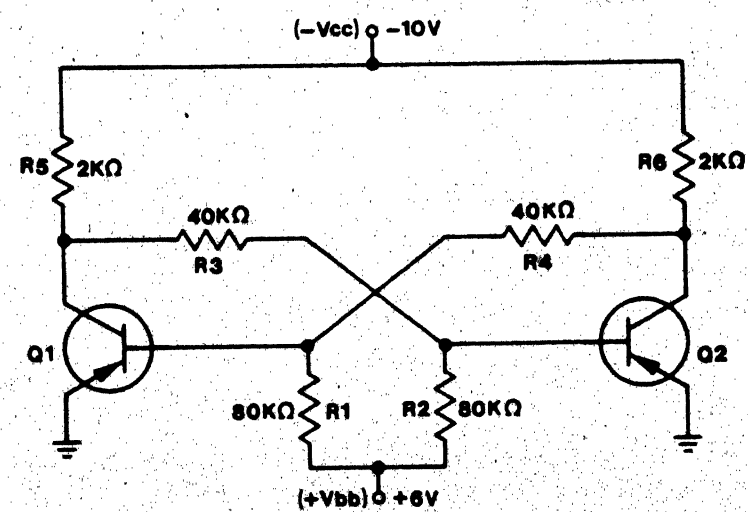
2. Bistable (flip-flop) multivibrators act like a two-position electronic _____.

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4. The flip-flop (bistable) multivibrator has two inputs and _____ output(s).

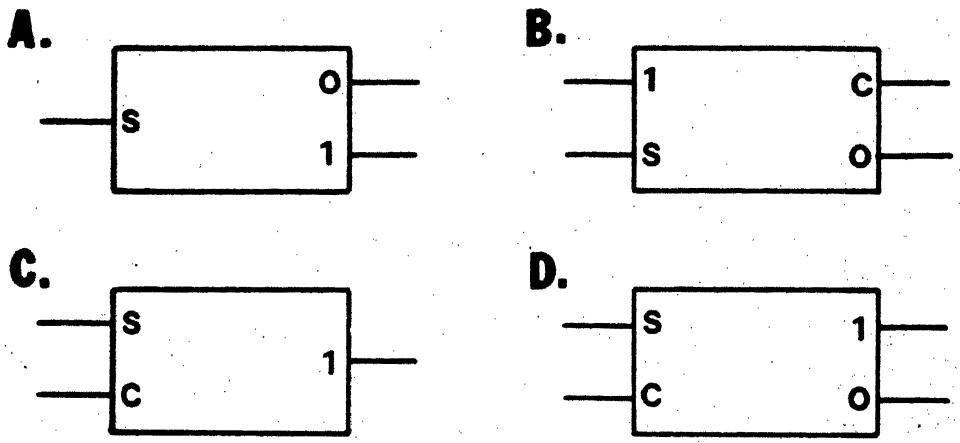
5. In a flip-flop multivibrator, when one transistor is saturated, the other transistor must be _____.

6. In the circuit illustrated, which voltage divider network supplies the bias potential to the base of Q1? _____.

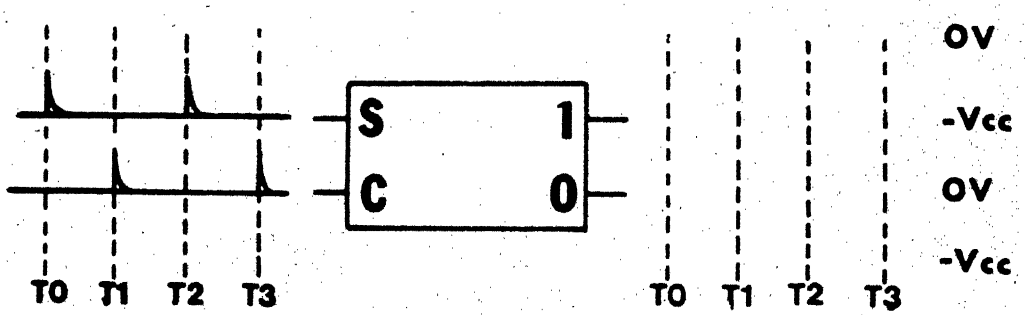


7. To change the state of a flip-flop multivibrator (illustrated in question #6), a (positive/negative) pulse may be applied to the base of the saturated transistor.

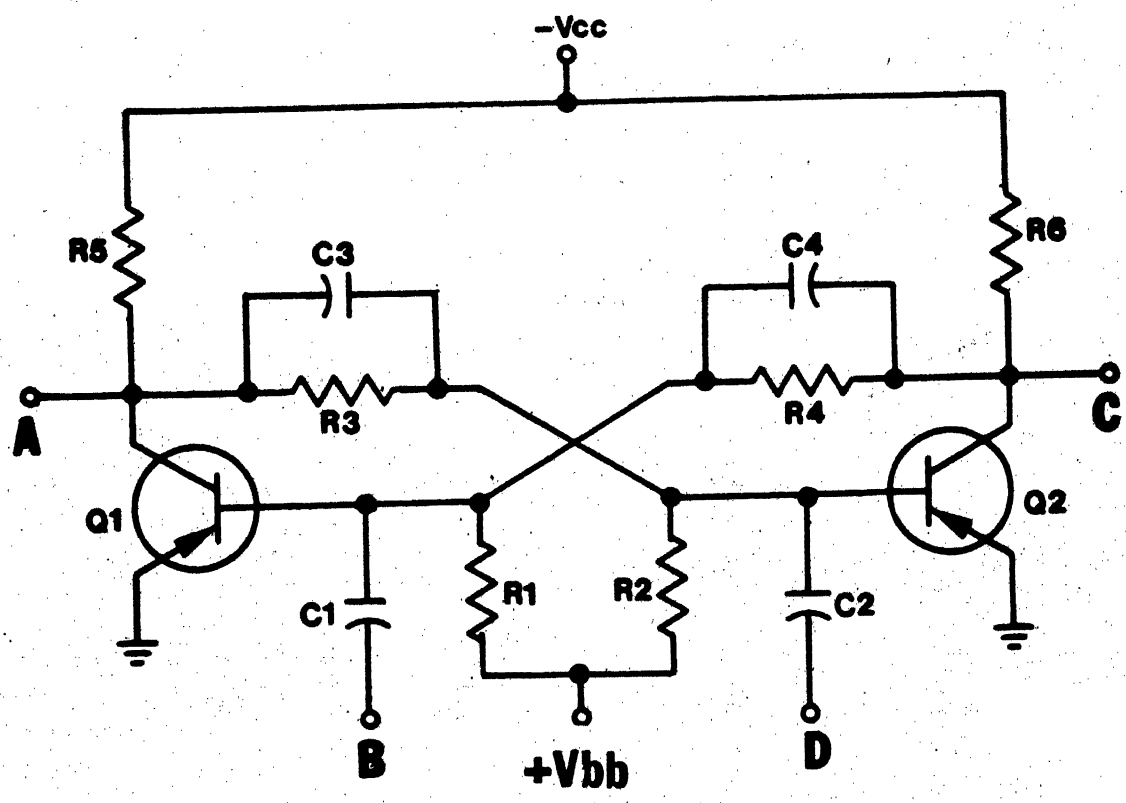
8. Which of the below illustrated symbols most correctly depicts a flip-flop (bistable) multivibrator?



9. Draw the "1" output waveform of the illustrated diagram. (The illustration is in a "clear" state prior to T_0.)



10. Label the inputs and outputs of the flip-flop multivibrator illustrated below.



11. To change the state of a flip-flop, a pulse is normally applied to the _____ transistor.

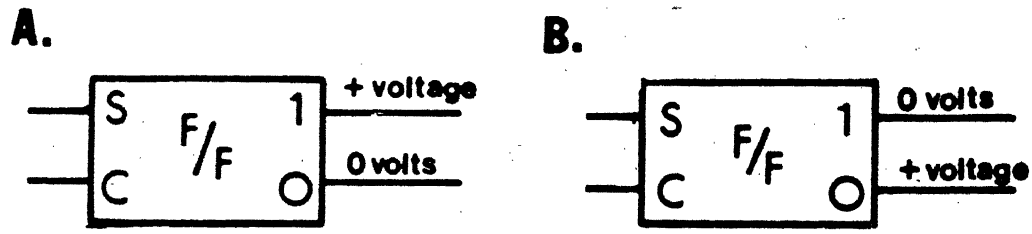
12. An input pulse of the correct polarity which changes the state of a flip-flop is called a/an _____ pulse.

13. A trigger applied to the SET input which causes the "1" output to go positive or negative, will at the same time cause the "0" output to equal _____ volts.

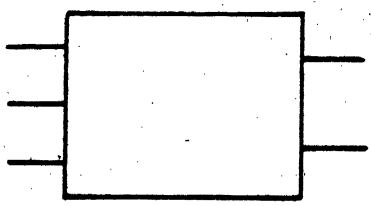
14. Define set state. _____

15. Define clear state. _____

16. Identify the state of the flip-flop in each illustrated block diagram.

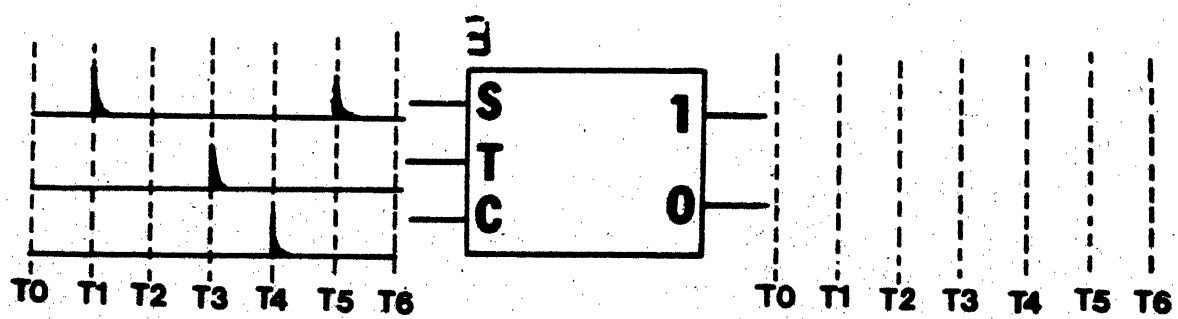


17. Identify each lead on the illustrated block diagram.

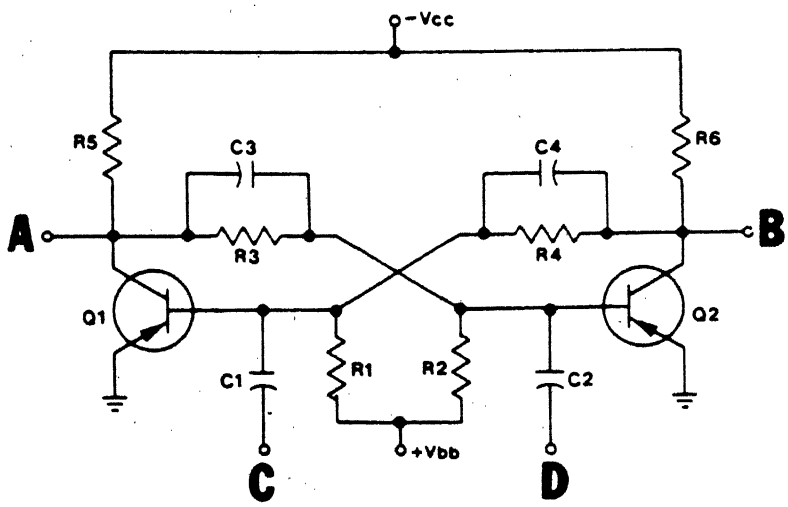


18. EVERY time a pulse is applied to the _____ input, the flip-flop will change states.

19. Assuming that the flip-flop is in the set state at T_0, draw the "0" output waveform with the inputs as shown.
(Assume the "1" state is a negative voltage.)



THE ILLUSTRATION BELOW WILL BE USED TO ANSWER QUESTIONS 20-22.



20. In the above illustration, if Q1 is saturated, Q2 is _____ and _____ will be the most negative output.

a. saturated, B
b. saturated, C
c. cut off, A
d. cut off, B

21. In the above illustration, with Q1 saturated, a _____ pulse applied to _____ will cause Q1 to cut off.

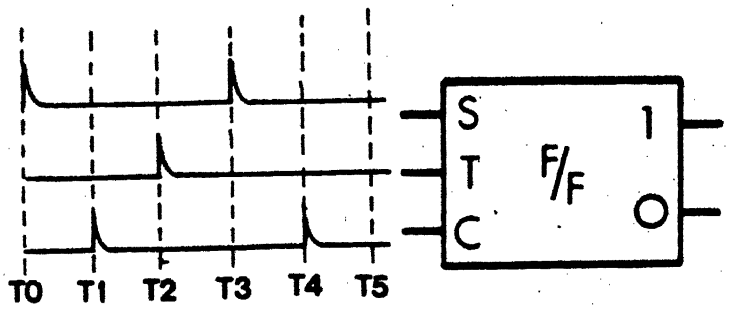
a. positive, C
b. negative, C
c. positive, D
d. negative, B

22. In the illustration above, Q1 is saturated. If a negative pulse is applied to C, what will happen?

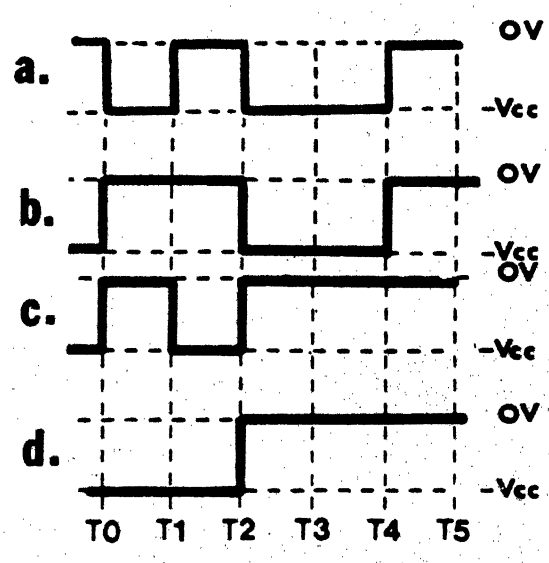
a. Q2 will become saturated.
b. Q2 will become cut off.
c. Q1 will cut off.
d. Nothing will happen.

23. A pulse that is used to cause a flip-flop to change states is called

a. a flipping pulse.
b. modulation.
c. a trigger pulse.
d. interference.



24. In the above illustration, what waveform would be seen on the "1" output with the inputs shown? (The flip-flop is in the clear state prior to T_0 and the Vcc is negative.)

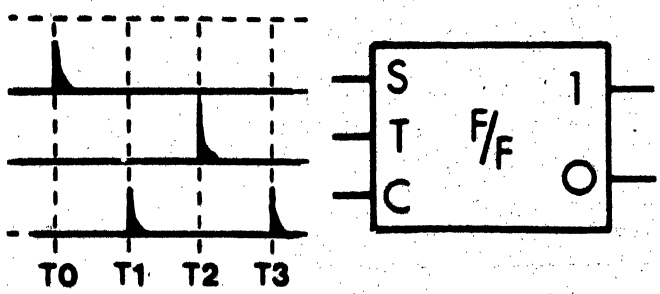


25. If a flip-flop is in the set state, a trigger on the _____ input will change it to the clear state. (Use the most complete correct answer.)

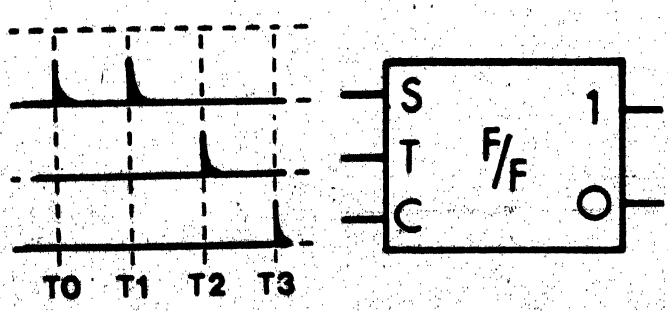
a. set, clear, or toggle
b. set or toggle
c. clear only
d. toggle or clear
e. toggle only

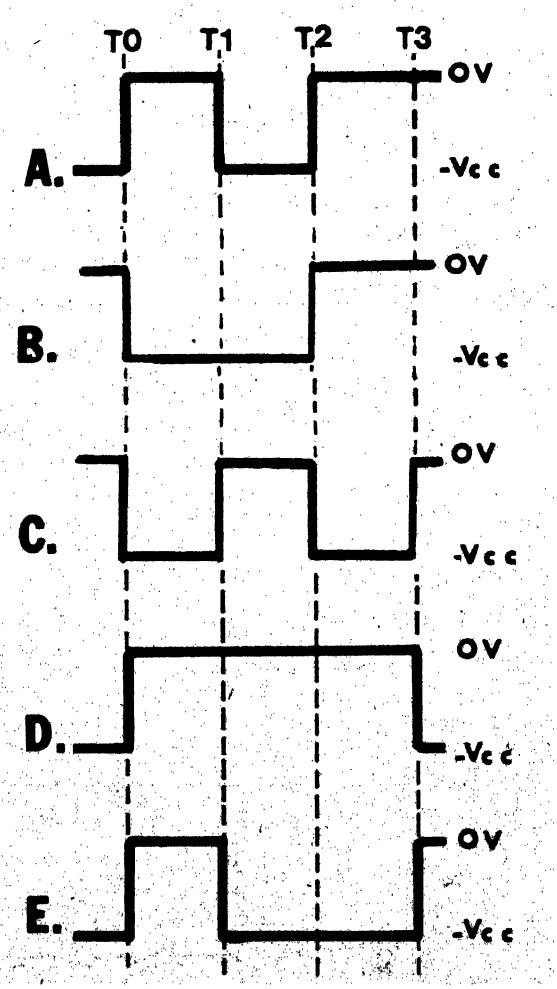
ON QUESTIONS 26 AND 27 MATCH THE INPUTS SHOWN WITH THE CORRECT "1" OUTPUT WAVEFORM. (The flip-flop is in the clear state prior to T_0 and Vcc is negative.)

26.



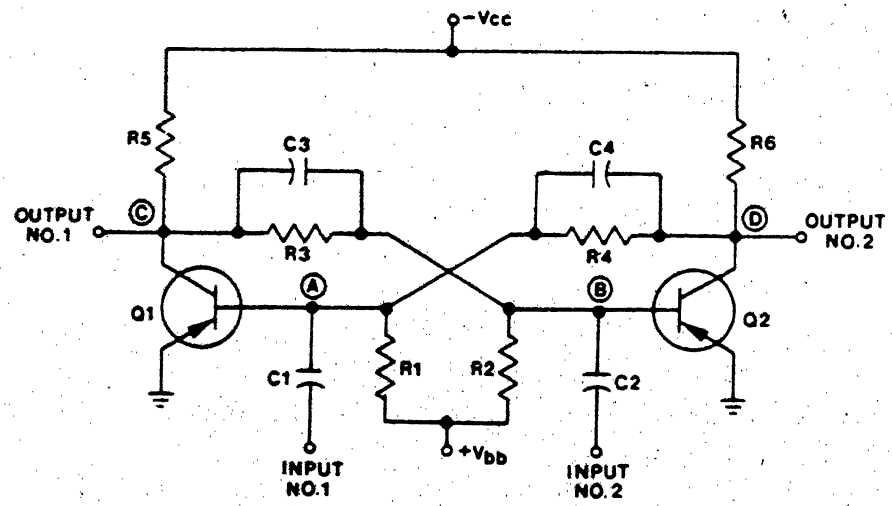
27.



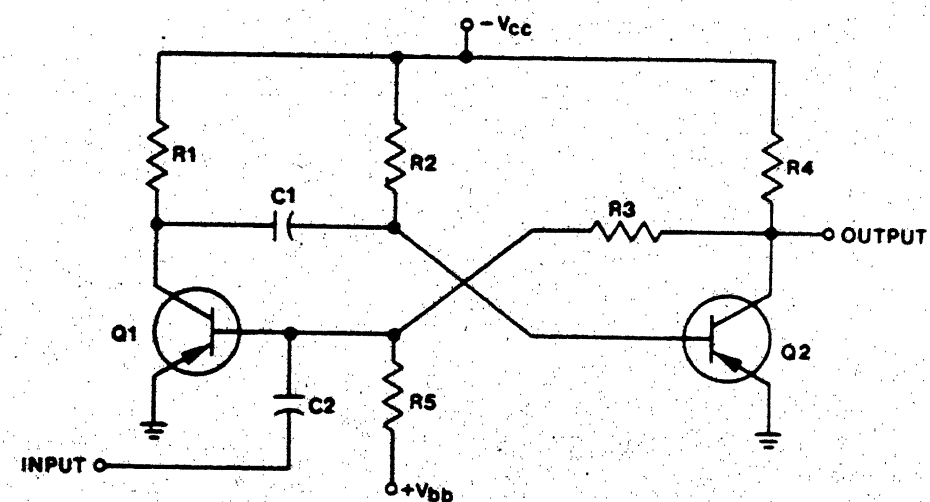


28. Which of the schematic diagrams below represents a flip-flop (bistable) multivibrator?

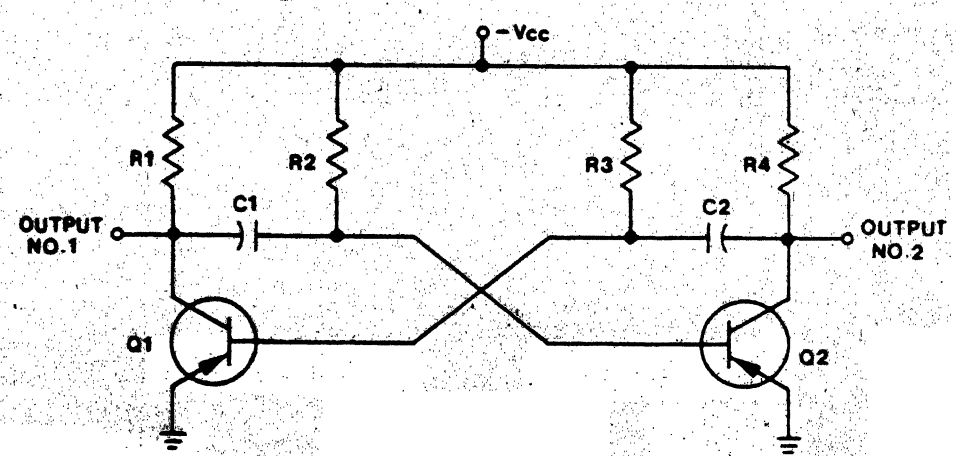
a.



b.



c.



CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

NOTES

SUMMARY
LESSON II

Astable Multivibrator Operation (Free-running)

An astable multivibrator is also known as a free-running multivibrator. It is called free-running because it freely alternates between two different output voltage levels. The output is a square-wave used for timing and gating purposes in electronic equipment.

The schematic of the astable multivibrator is shown in Figure 1.

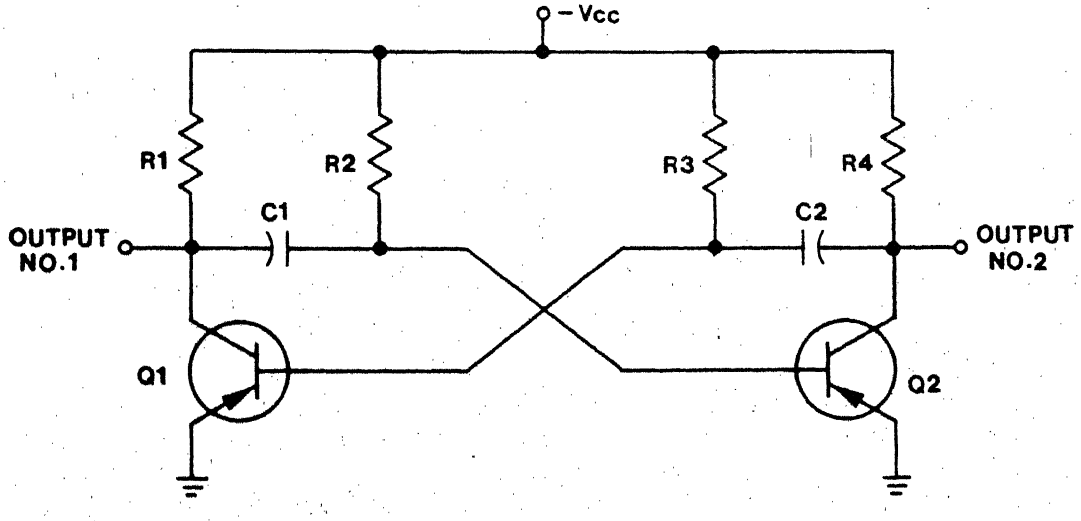


Figure 1

Like the flip-flop, the astable multivibrator has two outputs. But the astable multivibrator has no inputs. It is a type of oscillator since it generates a continuous output signal (a square wave) with no input signal.

When the circuit is energized, one of the transistors will cut-off. Therefore, one output will be a relatively high voltage (approximately -Vcc) when the other output is a low voltage (approximately 0 V).

Figure 2 illustrates an astable multivibrator with Q1 saturated and Q2 cut off.

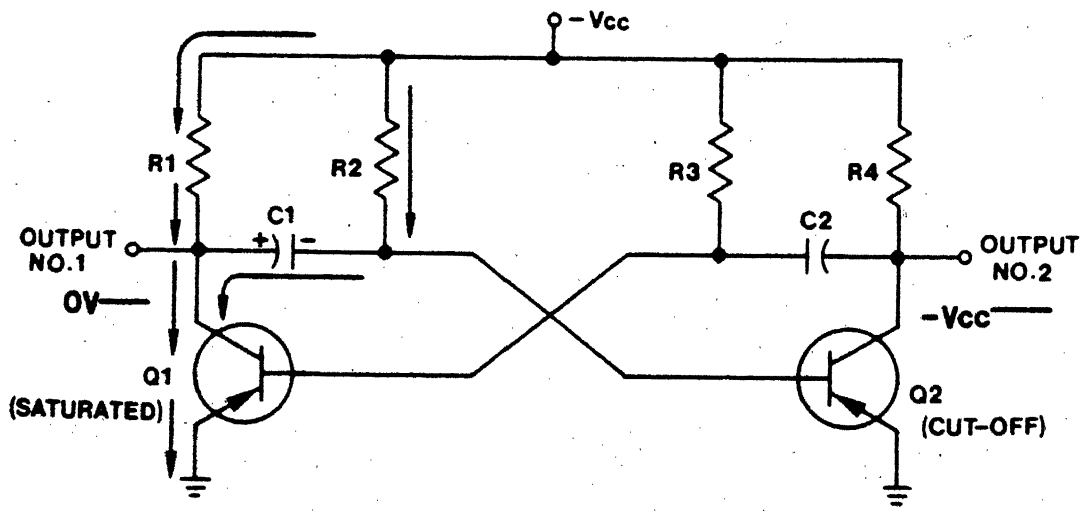


Figure 2

The circuit will remain in this state for a definite period of time. This period of time is determined by the time constant R2 X C1. Capacitor C1 is connected to the base of transistor Q2 (which is now cut off). As the right side of C1 charges (becomes more negative), the base of Q2 is also becoming more negative. When the base of Q2 becomes sufficiently negative to cause Q2 to conduct, Q2 will rapidly saturate. The resulting decrease in voltage at output #2 (from approximately -Vcc to approximately 0v) is transmitted through C2 to the base of transistor Q1. Transistor Q1 then goes into a state of cut off.

The conditions of the two transistors have now been reversed. Figure 3 illustrates Q1 cut off and Q2 saturated.

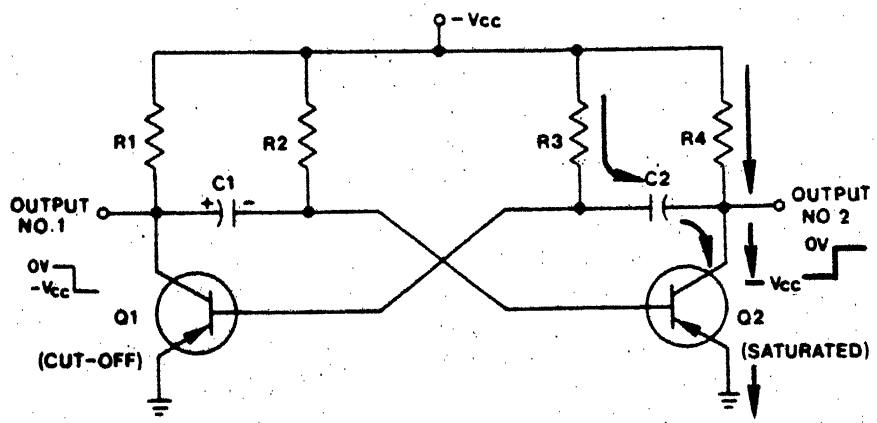


Figure 3

Now the left side of C2 will become more and more negative, depending on the time constant R3 X C2.

The base of Q1, consequently, becpmes more and more negative. After a definite period of time, Q1 will again saturate and Q2 will cut-off.

The output voltage from transistor Q2 is illustrated in Figure 4.

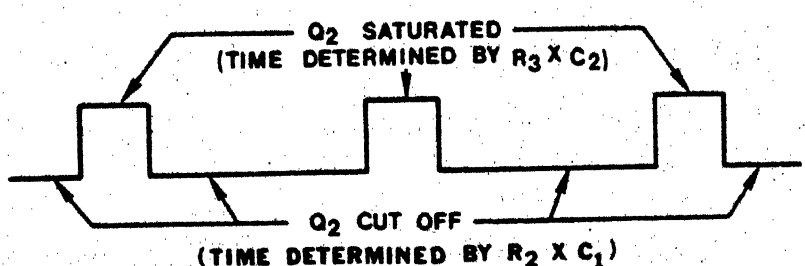


Figure 4

The output voltage (from either output) continually alternates from approximately 0 V to approximately -Vcc -- remaining in each state for a definite period of time. This output is used for various timing purposes -- operating like an electronic clock.

AT THIS POINT, YOU MAY PROCEED TO THE JOB PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

JOB PROGRAM
FOR
LESSON II

Astable Multivibrator

INTRODUCTION

The operation of an astable multivibrator will be demonstrated by performing the steps outlined in this Job Program.

EQUIPMENT AND MATERIAL

1. Oscilloscope
2. Device 6F16, TEMPLATE "H"
3. 1X Probe

PROCEDURE

I. Using all applicable safety precautions, energize the oscilloscope, obtain a line trace, and make the following settings;

 a. TIME/DIV to .5 milliseconds/div.
 b. DISPLAY MODE to Channel 1 .
 c. VOLTS/DIV to 2 VOLTS/DIV.
 d. Connect the 1X Probe to Channel "1" input.

II. a. Set up 6F16 using Template #H (Free Running Multivibrator) and the parts called for by the template.

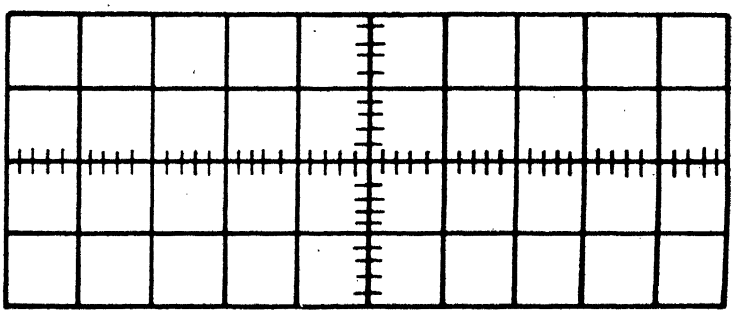
 NOTE: DO NOT INSTALL RESISTOR R7.

 b. Connect Channel "1" Probe to the output.
 c. Energize the 6F16 using the line cord.

III. You are now ready to observe the operation of an astable multivibrator.

1. Observe the output waveform and draw the observed waveform in the space below. NOTE: If there is no output, the circuit is probably balanced. To unbalance the circuit, momentarily insert R7 (390 ohm). Once the circuit is operating, R7 is not necessary; remove it

 NOTE: Insure your probe is grounded to 6F16.

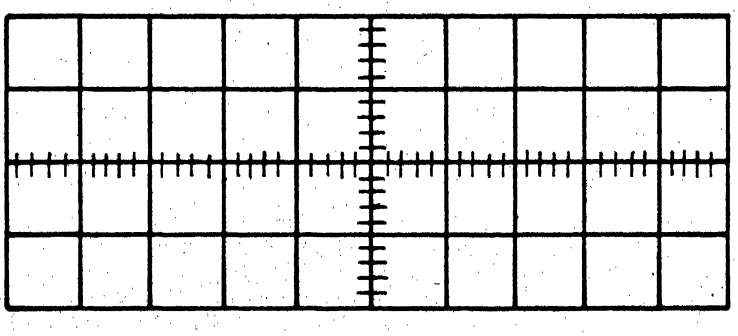


2. How long is Q2 in conduction? (Measure the time of the conducting half cycle.) _____

3. How long is Q2 cut off? _____

 Now you will set up the multivibrator for an asymmetric output. "Asymmetric" means the output will not be symmetrical; that is, one transistor will conduct longer than the other. To accomplish this, remove C2 (.05 µfd capacitor) and replace it with a .010 µfd capacitor.

4. Set the TIME/DIV on the oscilloscope to .2 msec/div and record the waveform displayed on the oscilloscope in the space below.



5. What is the time of the conducting half cycle of Q2? _____

6. What is the time of the "cut off" half cycle of Q2? _____

CHECK YOUR RESPONSES TO THIS JOB PROGRAM WITH THE ANSWER SHEET. IF YOUR RESPONSES AGREE WITH THE ANSWER SHEET, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOUR RESPONSES DO NOT AGREE OR IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS JOB PROGRAM, REVIEW THE PROCEDURES OF THIS JOB PROGRAM, ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS OR CONSULTATION WITH LEARNING CENTER INSTRUCTOR UNTIL YOUR RESPONSES DO AGREE.

PROGRESS CHECK
LESSON II

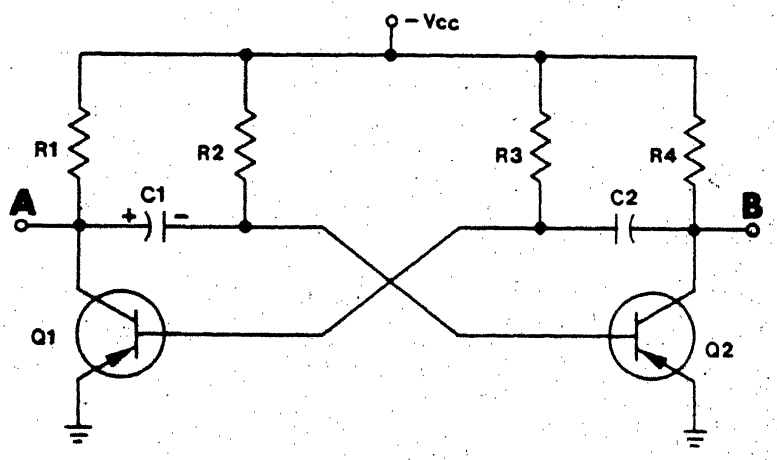
Astable Multivibrators

1. An astable multivibrator is also known as a/an _____ _____ multivibrator.

2. The astable multivibrator operates like a square-wave _____.

3. The astable multivibrator has _____ input trigger(s) and _____ output(s).

USE THE BELOW ILLUSTRATION FOR QUESTIONS 4 THROUGH 9.



4. In the figure above, which component(s) determine the amount of time Q2 is in a cut-off state? _____

5. If Q2 is cut-off, Q1 must be _____.

6. The rate of charging of C1 depends on the time constant produced by which components? _____.

7. The length of time that transistor Q1 remains cut off is determined by the charging rate of capacitor _____.

8. If Q1 is saturated, which of the following will occur when Q2 begins to conduct? (In correct order of occurance.)

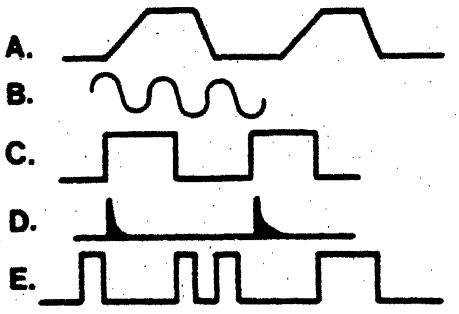
a. E_{R1} drops to 0V, E_{R4} rises to Vcc, C2 charges, and Q1 cuts off.

b. E_{Q2} drops to 0V, E_{R4} rises to Vcc, Q1 cuts off, and C2 charges.

c. Q1 cuts off, E_{R3} rises to Vcc, C1 charges, and Q2 saturates.

d. E_{R1} rises to Vcc, C1 discharges and Q1 breaks down.

9. The waveform at Point A will be most like _____ shown below.

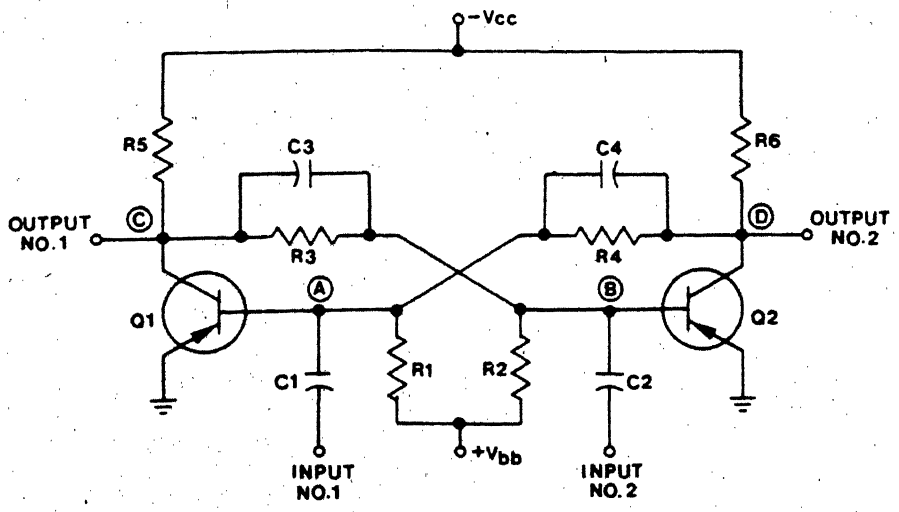


10. The astable multivibrator is used for

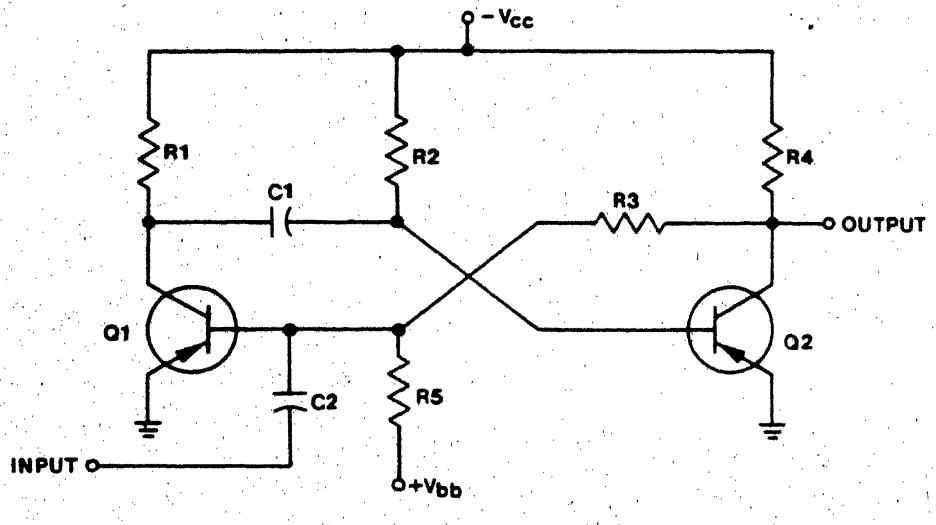
a. amplification.
b. timing.
c. regulation.
d. differentiation.

11. Which of the schematic diagrams below represents a free-running (astable) multivibrator?

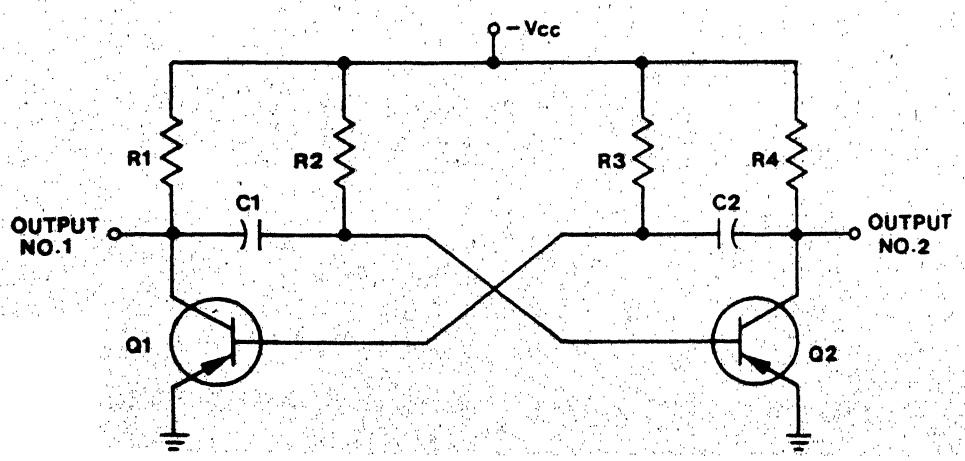
a.



b.



c.



CHECK YOUR RESPONSES TO THIS PROGRESS CHECK WITH THE ANSWER SHEET. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS IN THE PROGRESS CHECK CORRECTLY.

NOTES

ANSWER SHEET
FOR
JOB PROGRAM
LESSON I

Bistable Multivibrator

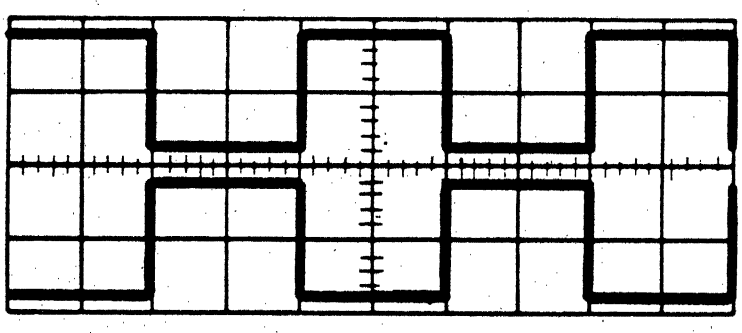
III.

NOTE: There are two possible answers to questions 1, 2, 3 and 5. If your answer to #1 is - 4 volts, use the first answer for 2, 3, and 5. If your answer is 0 volts, use the second answer for 2, 3 and 5.

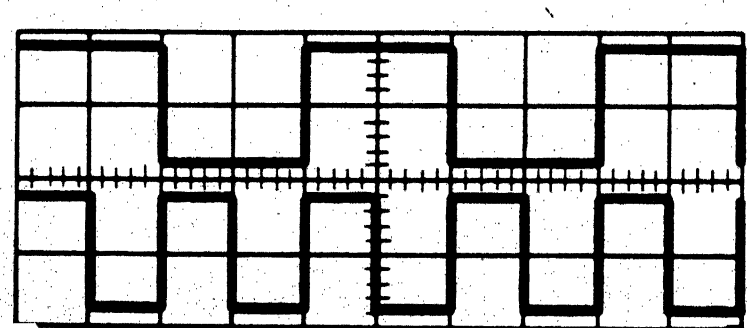
1. -4 volts 0 volts
2. 0 volts -4 volts
3. Q2 Q1
4. slight variations in component values. (or words to that effect)
5. NO YES
6. yes
7. Q1 conducting, Q2 cut off
8. NO
9. YES
10. Q1 cut off, Q2 conducting

IV.

3.



5.

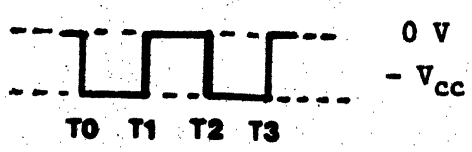
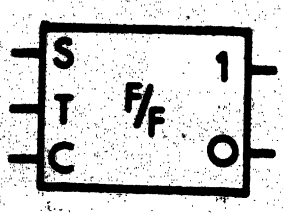


NOTE
Waveforms not shown to scale for purpose of phase & frequency relationship.

frequency is twice the output frequency. (or words to

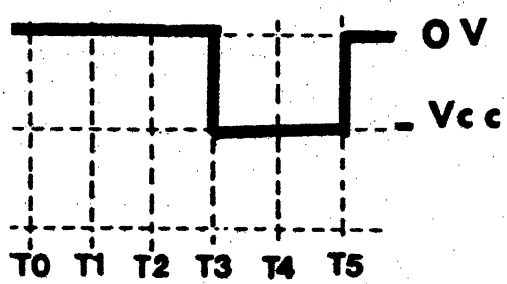
ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 1

Bistable Multivibrator Operation (Flip-Flop)

QUESTION NO.	CORRECT ANSWER
1.	two
2.	switches
3.	will
4.	two
5.	cut off
6.	R6, R4 and R1
7.	positive
8.	D
9.	
10. a.	output
b.	input
c.	output
d.	input
11.	saturated
12.	trigger
13.	zero
14.	A flip-flop is in a set state when there is a voltage at the "1" output and no voltage at the "0" output. (or words to this effect)
15.	The clear state of a flip-flop is the state in which the "1" output is zero volts and the "0" output has voltage. (or words to this effect)
16. a.	set
b.	clear
17.	

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON 1 (Cont'd)

Bistable Multivibrator Operation (Flip-Flop)

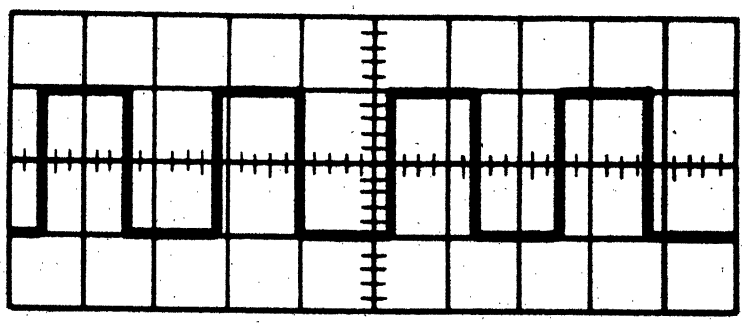
QUESTION NO.	CORRECT ANSWER
18.	toggle
19.	
20.	d.
21.	a.
22.	d.
23.	c.
24.	a.
25.	d.
26.	c.
27.	b.
28.	a.

ANSWER SHEET
FOR
JOB PROGRAM
LESSON II

Astable Multivibrator (Free Running)

III.

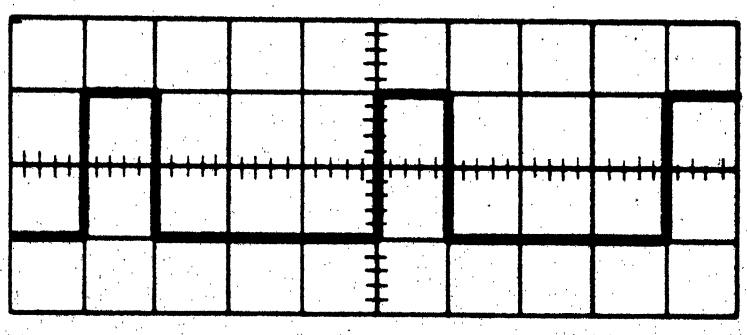
1.



2. .64 millisec.

3. .6 millisec.

4.



5. .2 millisec

6. .6 millisec

ANSWER SHEET
FOR
PROGRESS CHECK
LESSON II

Astable Multivibrator Operation (Free Running)

QUESTION NO.	CORRECT ANSWER
1.	free running
2.	oscillator or generator
3.	zero (No), two (in that order)
4.	R2 and C1
5.	saturated
6.	C1 and R2
7.	C2
8.	b.
9.	c.
10.	b.
11.	c.

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